Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia (1993), I(1): 38-50

PHYSICAL EFFECTS ON THE BEHAVIOR OF LITTORINA LITTOREA (L.)

(Pengaruh Faktor Fisika Terhadap Tingkah Laku Littorina littorea (L.))

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ABSTRACT

In this experiment, gastropods *Littorina littorea* (L.)were reared in salinities of 9-33 ‰. The animals could not survive in salinities of less than 8 ‰ for extended period. In salinities of 15,6-19,4 ‰ they are more active with or without light compared to other salinities. The gastropods perform a considerably decreased activity with decreasing salinity.
Key words: *Littorina littorea*, behavior, salinity, light

ABSTRAK

Gastropoda, *Littorina littorea* (L.) dipelihara pada salinitas antara 9-33‰ . Hewan tidak dapat bertahan hidup pada salinitas kurang dari 8‰ . Pada salinitas antara 15.6-19.4‰ hewan tampak lebih aktif dalam kondisi dengan atau tanpa cahaya. Penurunan tingkat aktifitas umumnya terjadi dengan menurunnya salinitas media.
Kata-kata kunci: *Littorina littorea,* tingkah laku, salinitas, cahaya

INTRODUCTION

It is a fact that environmental factors control animal distribution, and by any means the animals always perfectly adapt to their surroundings. The point is that most animals are pratically limit their distribution by their habits and reactions. The ultimate process is that they choose a suitable place where breeding and physiological requirements

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are achieved (Elton, 1966). The periwinkles (snails), *Littorina littorea* (L.), are found in great numbers in littoral zones in many places throughout the world. However, the species is only abundant on exposed rocky shores (Hylleberg and Christensen, 1978). In our study area, Ronbjerg, Denmark, these animals spread over littoral fringes among scattered rocks.

The objective of our experiments is to show that some physical factors such as salinity and light influence the behaviour of periwinkles, *Littorina littorea*, and to study whether any adaptation to those parameters can be observed.

MATERIAL AND METHODS

The animals were obtained from rocky shore near harbour in Ronbjerg, and transferred to a stock tank with salinity of 23 ‰ and temperature of 16.6 °C for acclimatization. The animals chosen for laboratory experiment were taken from the stock tank, then they were kept in some aquaria under typical salinity and temperature controlled of sea-water intake before they were used in the experiment. The specimens for the experiment were lifted from the water and let the water drained from the shell, then kept in aquaria over night to reveal the presence of any weak individuals. No food was put in during the experiments.In these experiments, various salinities of sea-water were set up and obtained by diluting (aged) the sea-water with distilled water or adding some salt to the sea-water. The animals were put directly into the water without previous adaptation.

The experiment consists of four stages of observations:

- **Test I**. This test is to find roughly, how they are able to tolerate salinity and to set the maximum and minimum of the salinities used in further observation. In this test, six animals which consist of 3 small snails and 3 larger ones were placed in some jars with salinities of 10, 12, 15, 19, 24, 30 and 33‰. Size distribution of the snails resulted from transect sampling using 1 x 1 m^2 frames is shown in Figure 1, and has a mean range of 1,42 ± 0,93 cm, the small was referred to an individual having size of less than 1,42 cm.

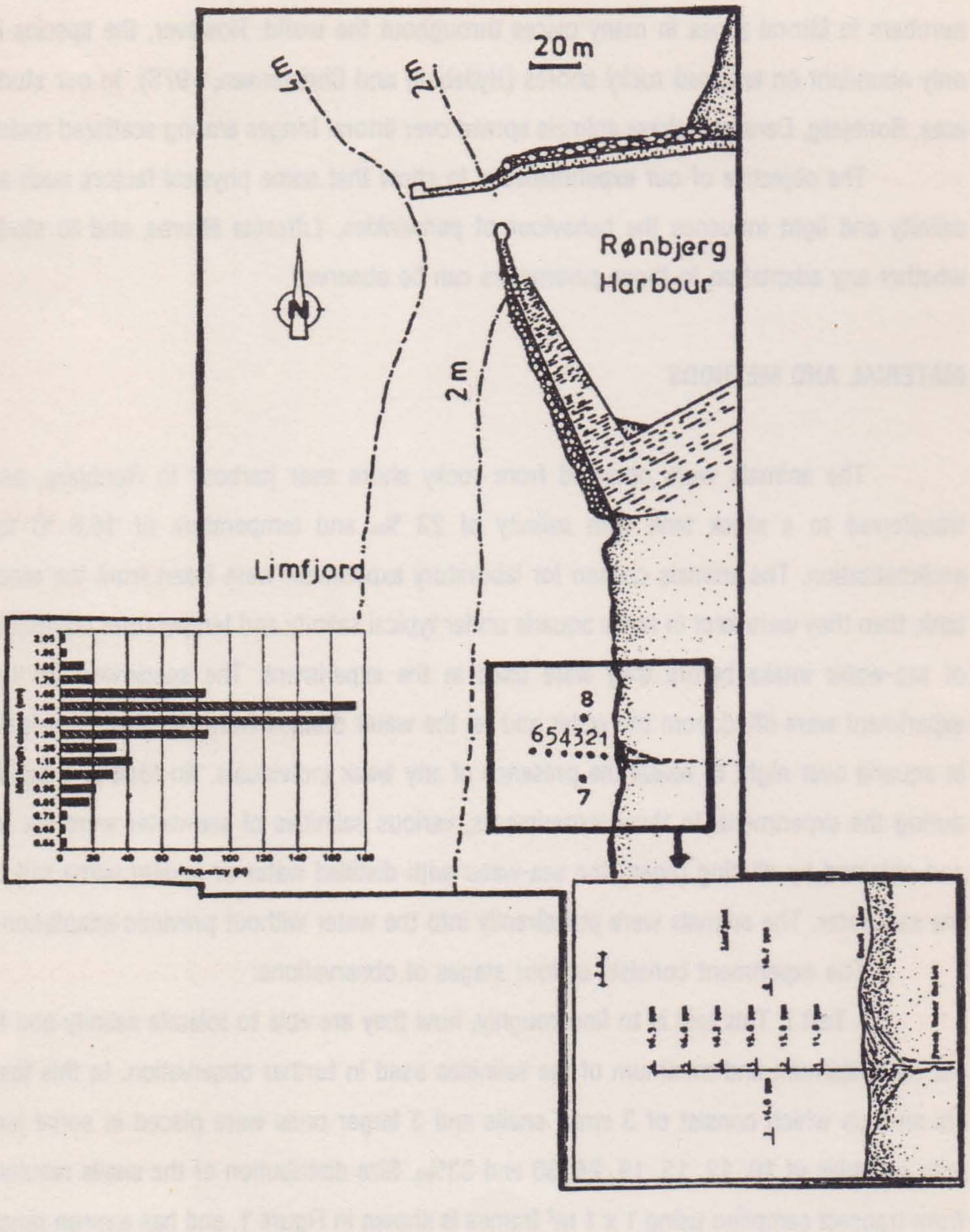


Figure 1. Map showing sampling areas in Ronbjerg

- **Test II**. This test is to observe the activity of periwinkle in several levels of salinities. Based on the results of the former test, six pairs of 500 ml jars were fulfilled with saline water of 30, 24, 19, 15, 12, and 10 ‰ respectively. The water was kept being unchange during the experiment. The snails were then put in the jars. The activity of the snails was observed at least once daily in accordance with the scale given by Arnold (1972) *in* Rosenberg and Rosenberg (1973). We used scores to classify the activity of the snails. The scores were:

5 ..... Moving

4 ..... Attached to cover or above water line

3 ..... Attached to side, below waterline

2 ..... Attached to bottom

1 ..... Foot extended from the shell

0 ..... Inactive, idle within the shell

The animals were placed back on the bottom after their activity had been scored.

- **Test III**. This stage was identical to the second with the exception that salinity was changed directly for every 12 hours. This test started with a salinity of 24 ‰ which in second test has shown the highest score of activity. In this test, two series of observations were set up. In the first serie, salinity was reduced from 24 ‰ to 15 ‰ for every 12 hours which in field observation is a border salinity to limit its distribution. The experiment was set up with changes of salinity in steps of 24 --› 19 --› 15 ‰ and back to the origin as in the start. In the second serie, salinity was increased for every 12 hours from 24 ‰ to 33‰ in the steps of 24 --› 30 --› 33 ‰ salinity back to 24 ‰.

- **Test IV**. This test is to know more about light effect to the activify of *L. littorea*. A tube with the diameter of 6,37 cm and height of 135 cm with 9 holes was prepared. Nine levels of salinities: 9, 12, 15, 18, 21, 24, 27, 30 and 33 ‰ were set up in 500 ml jars. It was allowed a day to get a stable stratification of salinity. Ten specimens were placed in the tube. Then in further observation, the tube was wrapped by aluminium foil with a hole for observation window, and a 60 watt lamp was used as a source of light. On

the final observation, stratification of salinity and dissolved oxygen were determined. Salinity was measured with conductivity-meter and Winkler methods are used to measure oxygen concentration.

The experiments were set up at the Marine Laboratory Ronbjerg Station, Aarhus University of Denmark, from June 19, 1991 to June 26, 1991. Beside the tests, observation in the field was also conducted in comparison to its behaviors in the laboratory.

All of the experiments, except Test I, were treated both in light and dark condition, and specimens were distinguished in size. The results were plotted as curves and statistically analyzed with Wilcoxon's stratified-sum test. A simple regression analysis was applied to know the trend of the activity.

RESULT

In Test I, *Littorina littorea* nearly do not show any activity in salinity of 10 ‰, except for a few animals which still attach to the glass wall. They were active completely in 8 ‰. This is similar to the specimens being kept in 33 ‰.

In the second test using different constant salinities, there is statistically no difference between the small and the larger snails in the pattern of activity both in light and dark jars ($p<0.05$). The similarity of activity pattern seems to occur in 29, 24, and 19 ‰ both in light and in dark jars (Figure 2 and 3).

The snails are active after a period of adaptation which will take about 12 hours. This fact is especially shown in the larger size when the activity is remarkly shown at the second 12 hours of observations. In the mean time, the larger snails are more active and tend to move out above water level and remain there. For example, in the light jar at 24 ‰, the activity of specimens from larger size is scored more than 3 which indicates that the specimens attach to the jar wall or on the cover of the jar bellow or above water line.

The small animals are frequently found inactive and idle within its shells such as in 10 and 15 ‰ in light and in dark jars. The phenomenon is more frequently shown in dark condition.

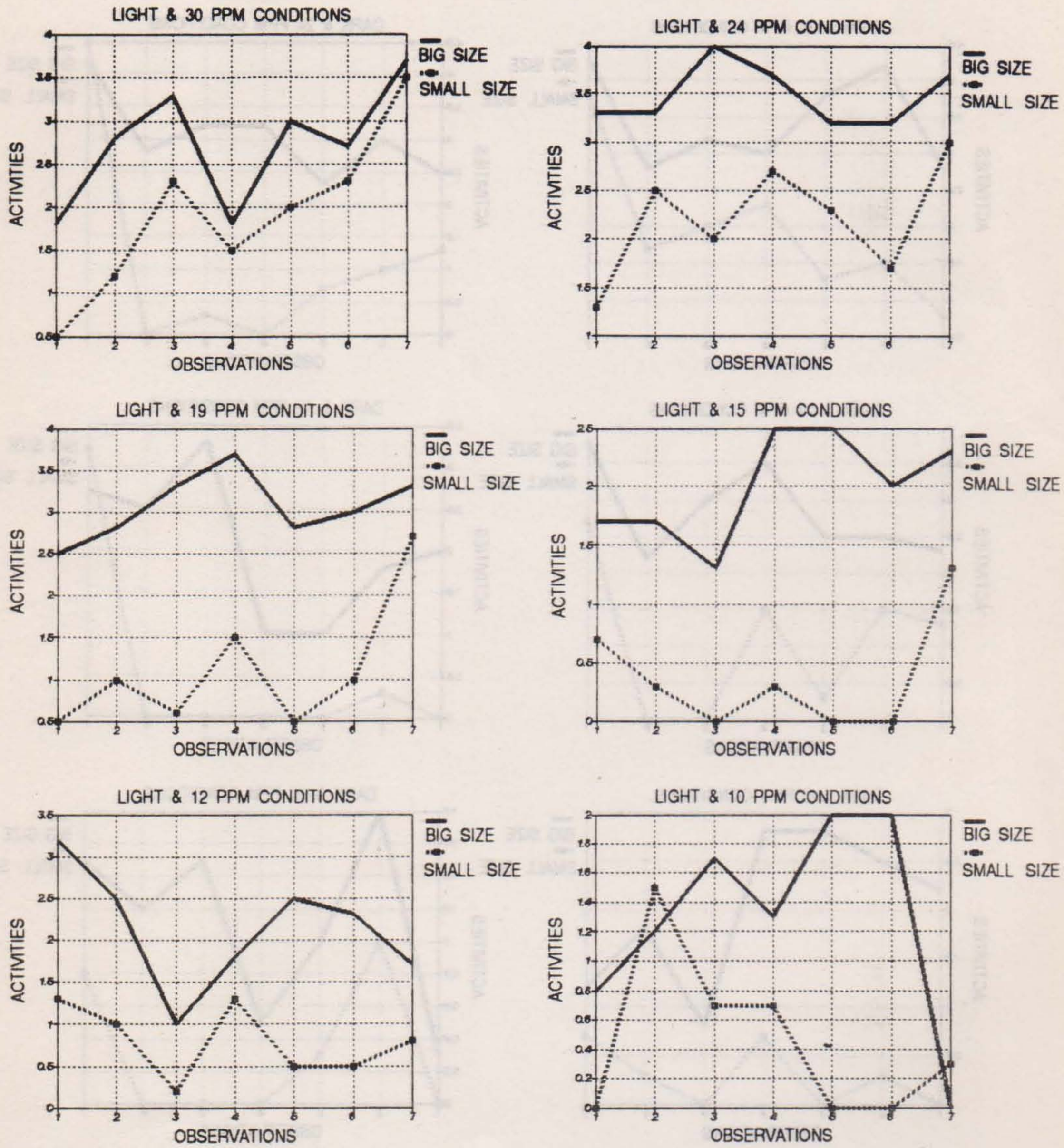


Figure 2. The activity of *Littorina littorea* in relation to salinity, exposed to light.

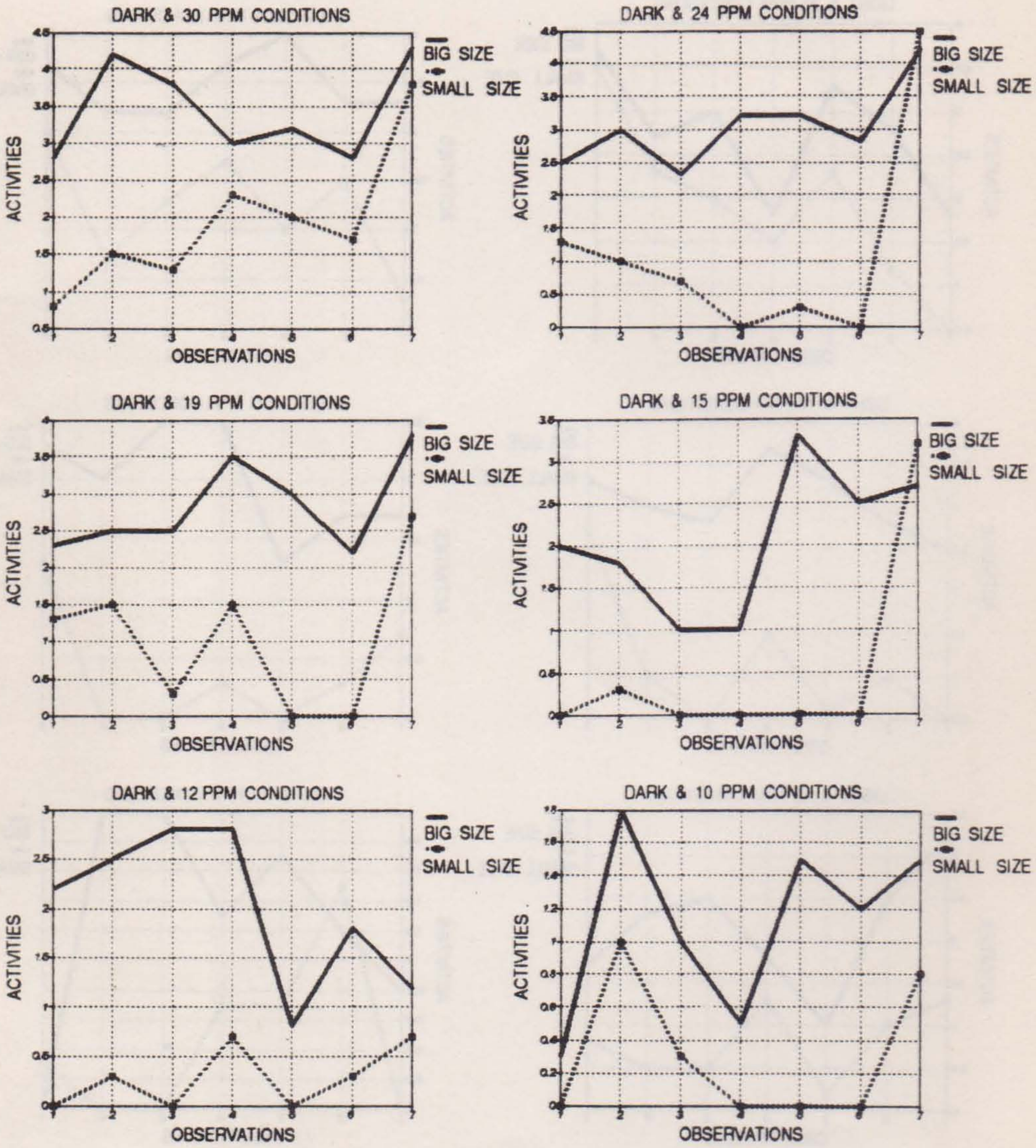


Figure 3. The activity of *Littorina littorea* in relation to salinity, exposed to dark condition.

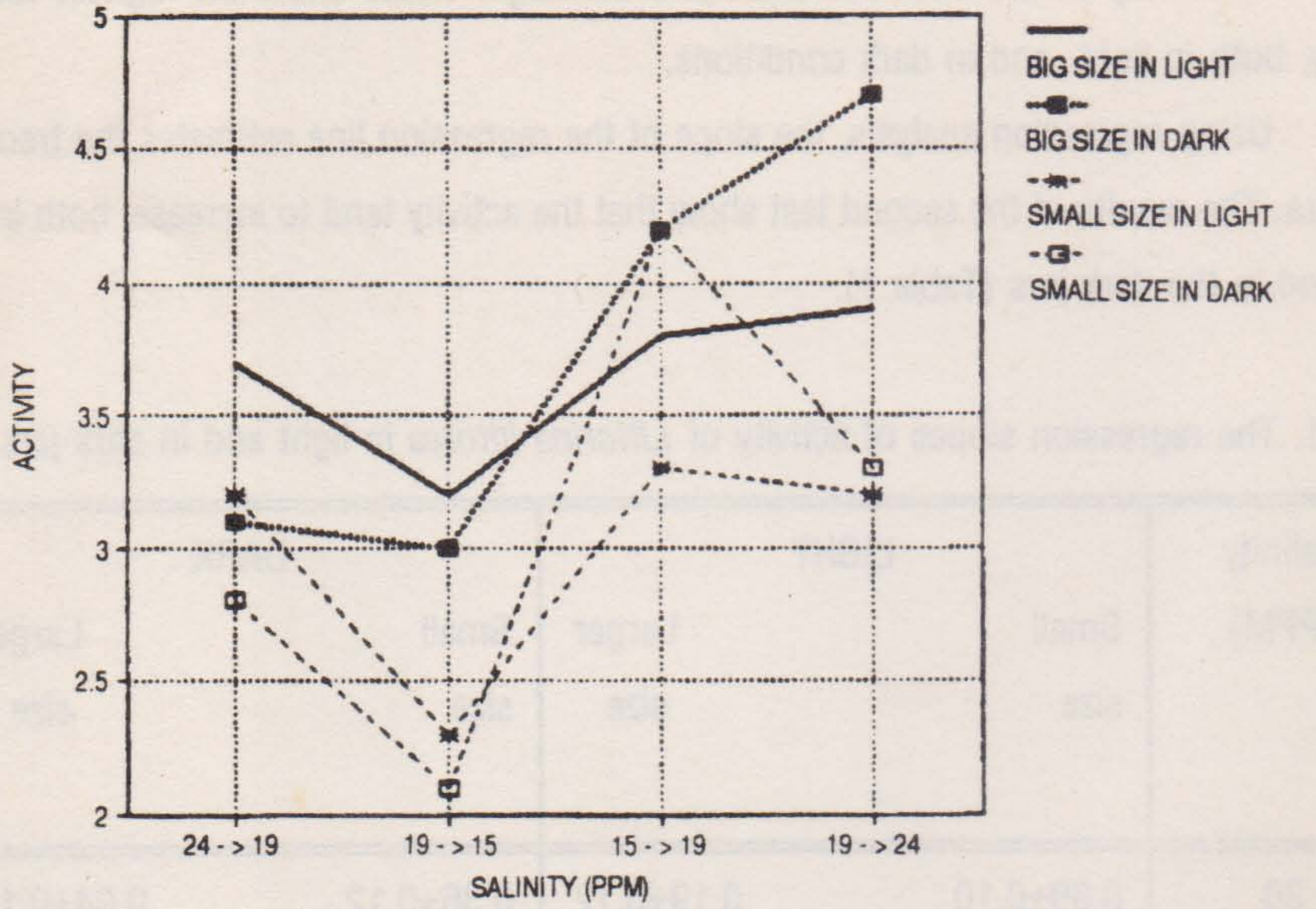
In salinity 30 ‰ both the small and the larger snails show the highest rate of activity, both in light and in dark conditions.

Using regression analysis, the slope of the regression line estimates the trend of activities. The results of the second test show that the activity tend to increase, both in the light and in the dark jars (Table 1).

Table 1. The regression slopes of activity of *Littorina littorea* in light and in dark jars.

Salinity (PPM)	LIGHT		DARK	
	Small size	Larger size	Small size	Larger size
30	0,39±0,10	0,19±0,12	0,36±0,12	0,04±0,13
24	0,14±0,11	0,01±0,07	0,20±0,09	0,20±0,09
19	0,23±0,13	0,08±0,08	0,03±0,21	0,16±0,11
15	0,04±0,10	0,13±0,08	0,32±0,20	0,21±0,15
12	-0,08±0,08	-0,12±0,14	0,08±0,06	-0,23±0,13
10	-0,10±0,11	-0,02±0,15	0,004±0,09	0,10±0,11

The third test starts with a salinity of 24 ‰ which in the second test has shown the highest rate of activity. The phenomena illustrated in Figure 4a show that on the average, the activity of animals concords with it should be for the range of the natural salinity. That salinity is about 19 ‰. In the second step salinity of 19-15 ‰ decreasing activity of the animals occur, then rise again when the salinity is set back to the salinity of 19 ‰, both in the light and in the dark conditions. Even when the salinity is increased to 24 ‰, the activity still increases. Exceptions occur with the small size specimens in dark condition.



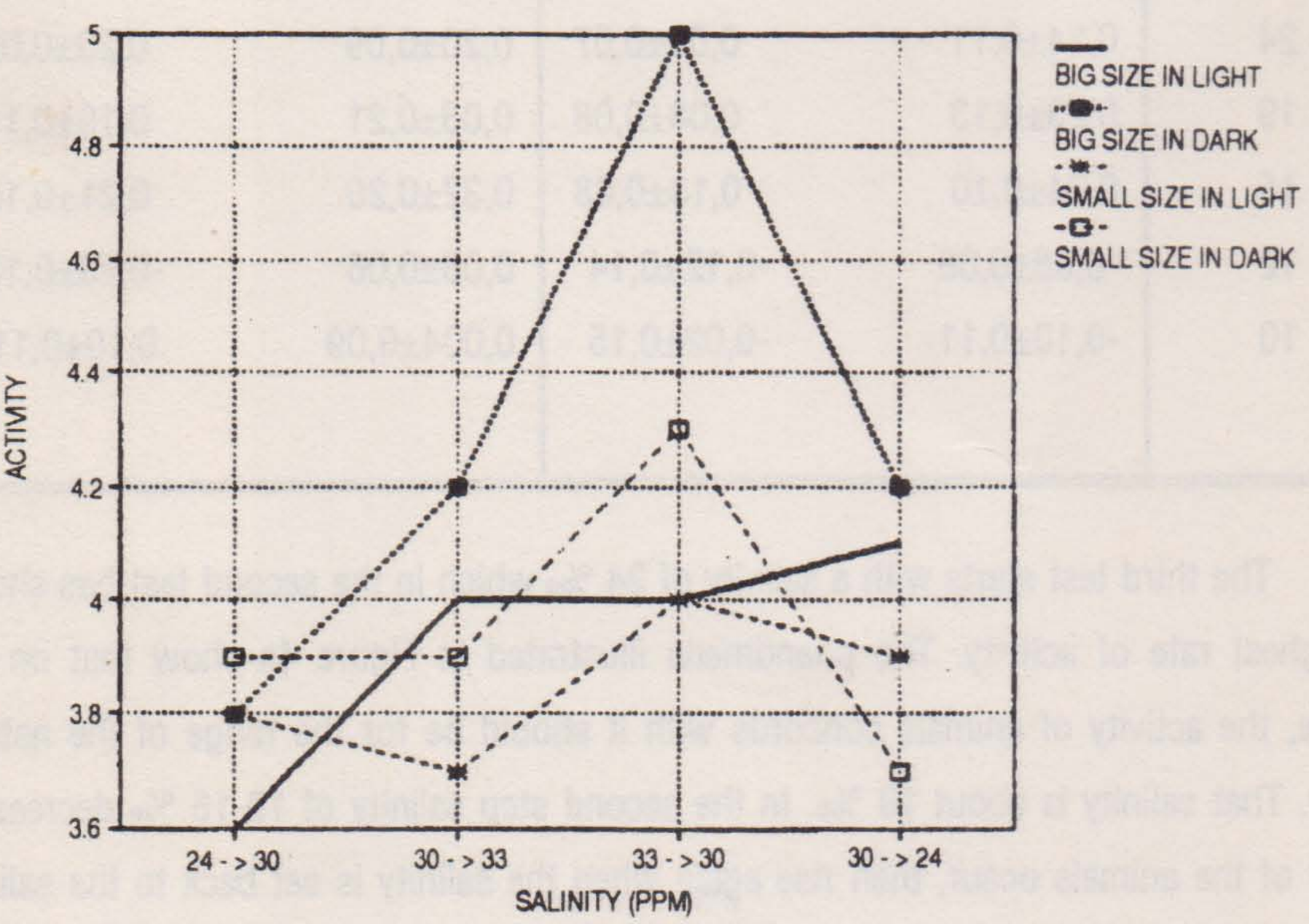


Figure 4. The average of activity of Littorina littorea in relation to a. decreasing salinity, b. increasing salinity.

Figure 4b shows that the activity the larger animals increases when salinity increases from 30 to 33 ‰. The small animals behave differently from the larger ones both in light and in dark conditions. Their activity rather decreases with increasing salinity. However, there is no difference ($p<0.05$) between the activity at the first increase of salinity (24-30 ‰) and at the second increase of salinity (30-33 ‰). Then, when salinity was reduced from 33 ‰ back to 30 ‰ the activity still increase. Most of the animals reduce their activities when the salinity is decreased down to 24 ‰.

The observation of test IV using long tubes gives a result as shown in Figure 5.

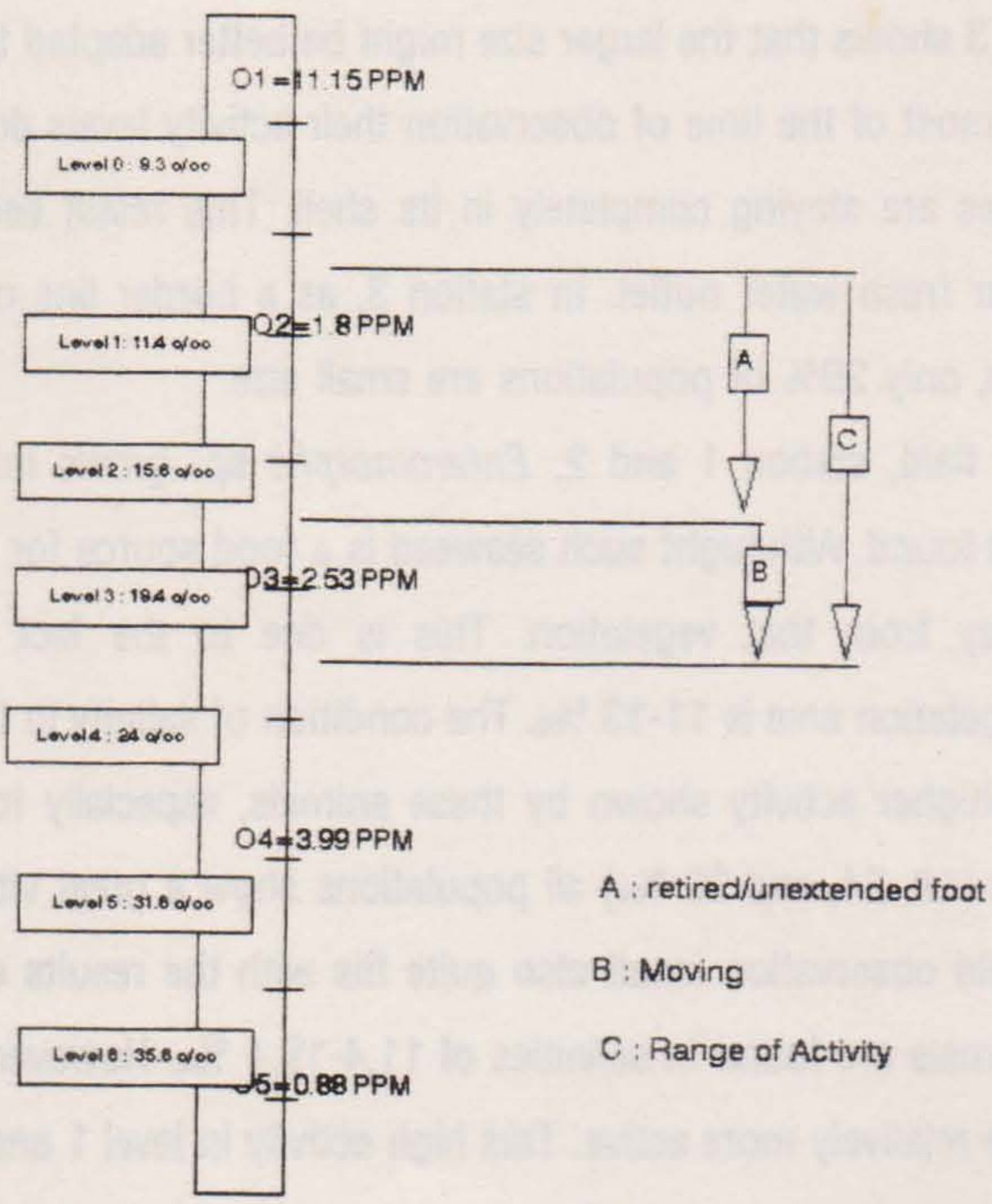


Figure 5. Gradient of salinity (‰) and dissolved oxygen (ppm) in relation to the activity of *Littorina littorea*.

Nearly 70% of *Littorina littorea* are found attach on the tube wall in "level" 1-3 as shown in Figure 5 where in this level dissolved oxygen is found as 1.81 ppm and 2.53 ppm at the lower level. Only 1 larger specimen is found in layer 5.

Wrapping the tube with an observation window in the next observation, shows that the specimen are not too attracted by the light. However, in level 2-3 one specimen is getting active.

DISCUSSION

The activity of the two size specimens of *Littorina littorea* can be distinguished in their scales, particularly at salinities of 15 to 30 ‰.

Figure 3 shows that the larger size might be better adapted to the salinities of 15 to 30 ‰ since most of the time of observation their activity levels do not smaller than 1. The smaller ones are staying completely in its shell. This result seems to fit with field observation near fresh water outlet. In station 3, as a border line of the distribution of *Littorina littorea*, only 29% of populations are small size.

In the field, station 1 and 2, *Enteromorpha* sp. grows intensely. There is no *Littorina littorea* found. Althought such seaweed is a food source for *Littorina littorea*, the snails stay away from that vegetation. This is due to the fact that the salinity in surrounding vegetation area is 11-13 ‰. The condition of salinity in the field might be the reason for the higher activity shown by these animals, especially for the larger size. In higher salinities (19, 24, and 30 ‰) all populations show a great vitality.

The field observation result also quite fits with the results of the test IV, where most of the animals are found in salinities of 11,4-19,4 ‰. However, in 15,6 to 19,4 ‰ they seem to be relatively more active. This high activity in level 1 and 2 is also proven by the lower dissolved oxygen measured in this level compared to that in other levels.

As many stimuli may influence the animals moving in gradient. The aggregation may not be due to a preference to a certain salinity concentration. However, in term of

salinity tolerance, a former study on the activity of three Scandinavian populations of *Littorina littorea* which were sampled from Gasovik (Swedish), Borno and Helsinger (Denmark) by Rosenberg and Rosenberg (1972) showed that a great vitality occur in salinity of 15,5, 22,5 and 30 ‰ and our experiment came out with the result mentioned above.

CONCLUSION

Salinity seems to be a stronger factor than the light in term of its effect to the activity of *Littorina littorea*. However, it needs more accurate experiment using several light intensities to be sure.

The results of laboratory experiments show that the specimens exhibit a quite good ability to withstand strong fluctuations of salinity. However, they prefer the range of salinities between 19 and 30 ‰.

Based on the experiment, for further investigation, it is suggested to use individual size larger than 1,4 cm, since it is more active compared to the smaller ones.

ACKNOWLEDGEMENTS

Financial support from Marine Science Program is gratefully acknowledged. Thanks are also given to the Director of Marine Laboratory Ronbjerg for giving us facilities for our experiment. Our sincere gratitude is given also to our supervisor Jorgen Hylleberg for his encouragements and interest in this work, and to Peter and Hakon, who carefully analyzed and solved the problems.

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